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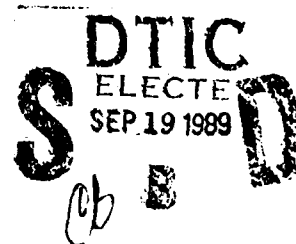
DEPARTMENT OF DEFENCE
DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION
AERONAUTICAL RESEARCH LABORATORY
MELBOURNE, VICTORIA

Propulsion Technical Memorandum 441

RAN VIBRATION ANALYSIS SYSTEM
OPERATORS' GUIDE (U)

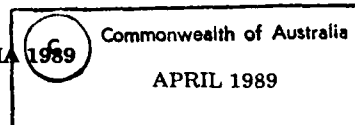
by

B.D. FORRESTER



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**RAN VIBRATION ANALYSIS SYSTEM
OPERATORS' GUIDE (U)**

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B.D. FORRESTER

SUMMARY

A computerized vibration analysis system consisting of hardware purchased by the Royal Australian Navy and software developed by Aeronautical Research Laboratory has been installed at NAS Nowra. The primary purpose of the system is to detect incipient failure of Wessex helicopter main rotor gearbox input pinions.



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1. INTRODUCTION.

This guide is intended to aid the operators in the use of the RAN Computerized Vibration Analysis System installed at NAS Nowra. This system has been designed to provide early failure detection for the Wessex main rotor gearbox input bevel pinion. Signal averaging and enhancement techniques are used on in-flight vibration recordings to give an assessment of the input pinion condition. The system is menu driven and also provides facilities for file management, floppy disk handling and system updating. It provides an operating environment which requires no user knowledge of the computer's native operating system.

The main body of this guide provides instructions for the normal use of the system. Some rarely needed but important guide-lines, such as how to install the system, are given in the Appendices.

2. STARTING THE SYSTEM.

The system has been designed to automatically enter the Wessex Pinion Signal Averaging menu at start up. To eliminate possible problems in starting (booting up) the system, the following sequence should be used:

- (a) Connect the tape recorder to the Brickwall filter (Channel 2 of the tape recorder to channel 1 of the filter, Channel 4 of the recorder to channel 2 of the filter).
- (b) Switch on the filter.
- (c) Check that there is no floppy disk in the disk drive. Floppy disks should never be left in the drive while the computer is off.
- (d) Switch on the computer at the power point.
- (e) Place the key in the lock on the front panel of the computer and turn it clockwise. The computer should now go through its boot (startup) procedure and ask for today's date. Before you enter the date...
- (f) ...switch on the printer. Ensure that the paper perforations are just above the print head before you turn the printer on, otherwise output may not be correctly aligned on the page.
- (g) Enter the date (this is in the form 3-MAR-88, 20-JUL-88 etc.) and press the RETURN key. The computer will now ask for the time; this is optional. You can either enter the time in the form 8:30, 9:15 etc., or just leave it blank and press the RETURN key.

The system should now display the Wessex Pinion Signal Averaging menu.

3. WESSEX PINION SIGNAL AVERAGING.

The major function of this system is to detect cracks in the input pinion of the Wessex main rotor gearbox, although it is intended that other analysis functions will be added in the future (e.g. analysis of other Wessex gears as well as Sea-King and possibly Sea-Hawk gears). As you will rarely need to use other menus at present, the system enters the Wessex menu directly to save time (see Figure 1).

On the screen you will see 'RAN VIBRATION ANALYSIS SYSTEM' in large type across the top. Below this is a 'status' line containing the words:

'Version' followed by a number in bold type. This identifies the current software version installed.

'Wessex Pinion Signal Averaging' in bold type in the middle of the line. This tells you which part of the system you are currently running.

'File'. This indicates the file which is currently selected. Initially nothing will follow this, but when you select or create a file, the name of the file will be displayed in bold type.

At the bottom of the screen will be a line which gives brief instructions on how to use the current menu.

In the middle of the Wessex menu you will see a number of options which you can select by moving the cursor onto the one you require. To move the cursor, use the cursor keys on the keypad immediately to the right of the main keyboard. The computer will beep if you hit a key it doesn't recognize. When the cursor is on the option you require, press the RETURN key.

4. WESSEX VIBRATION DATA INPUT AND ANALYSIS.

To input vibration data from a Wessex recording and analyse it, select the AUTO function from the Wessex Pinion Signal Averaging menu. This will automatically read vibration data from the tape recorder, calculate the signal average and perform the analysis.

The computer will ask you to enter details of the gearbox and particulars of the recording (date, tape number, torque etc.). It will usually be necessary only to analyse the recording with the largest torque.

NOTE: Only recordings for WESSEX gearboxes should be used. Attempts to analyse vibration from other gearboxes will produce invalid results.

To ensure correct operation of this procedure, follow these steps.

- (a) Wind the tape to the correct meter location. Make sure that it is the right tape.
- (b) Double check the tape by listening to the:
 - Vibration signal on channel 2 - make sure it is present.
 - Alternator signal on channel 4 - this should be a constant hum - if there is no alternator signal, the recording cannot be used.
 - Voice track on channel 1. If present this should give a further check on correct tape location.
- (c) After you are sure the tape is OK, stop the tape at the correct location (slightly after the start of the recording), and switch the speed to 1.5 ips.
- (d) After the tape details are entered, the computer will ask you to start the tape and press the RETURN key. Do this. The computer will now read data from the tape.
- (e) When the computer has read in enough data, it will ask you to stop the tape recorder (do so) and it then asks for:

Range Scale - this is the range scale setting of the accelerometer amplifier (listed in the right hand column of the Aircraft Vibration Analysis Record Sheet). Usually it is 50 g/V, if so, just press RETURN, otherwise type in the value before pressing RETURN.

Gain Setting - this is the position of the 'Gain' knob on channel 1 of the Brickwall filter. It should normally be set to '0'dB in which case press the RETURN key. If it is not set at '0', type in the setting and press RETURN.

The computer scales the data according to the Range Scale and Gain Settings you have entered, in preparation for the signal averaging. This will take a few minutes. You will see the message 'Scaling Rotation Data', indicating that the alternator signal from channel 4 of the tape is being scaled and checked. This will be followed by the message 'Scaling Vibration Data', indicating that the computer is scaling and checking the vibration data from channel 2 of the tape.

After the scaling is completed, the screen will clear and the words 'Calculating Average' will be displayed on the status line. The signal average is now being calculated and you will not be required to do anything for a while. NOTE: While the average is being calculated the word 'Working' will flash on and off in the top left of the screen, just below the version number. This indicates that everything is working correctly.

After the calculation of the signal average has been completed, the data will be analysed to assess the condition of the input pinion. A graph will appear on the screen and remain there for a few minutes; don't worry, the computer hasn't stopped, it is just formatting the graph so it can be plotted on the printer.

At the end of the analysis, the computer will print the results and return to the Wessex Pinion Signal Averaging Menu. The file name of the newly created signal average will appear in bold type in the 'File' section of the status line to indicate that it is also the currently selected file. You can now analyse further data or perform other functions.

5. OUTPUT - WESSEX PINION SIGNAL AVERAGES.

5.1 The Signal Average.

When you run the Wessex Pinion Signal Averaging AUTO or ANALYSE AVERAGE command, you will receive an output on the printer which will contain a graph of the signal average, identification of the source of the data and assessment of the condition of the input pinion (refer to Figure 3).

- (a) **The Graph:** The graph plotted is the 'signal average' of the input pinion. This should normally have a number of peaks and troughs which is an integral multiple of 22 (i.e. 22, 44, 88 etc.). The graph represents the vibration produced by one complete revolution of the input pinion, which has 22 teeth.
- (b) **RMS Level:** This is the RMS level (in g's) of the signal average.
- (c) **Largest Component:** This is the dominant component of the signal average given as a number of 'orders'. The number of orders represents the frequency of an event per revolution of the gear. Therefore, if the largest component is listed as 22 orders, this indicates a frequency of 22 times per revolution of the gear (i.e. the tooth

meshing frequency). The largest component listed will normally be an integral multiple of 22.

- (d) **Band pass lower and upper limits:** These are the limits (in orders) of the 'band pass filter' applied in the analysis of the signal average. These will normally be 14 orders either side of the largest component. The bandpass filtering is part of a signal enhancement technique developed at ARL for the assessment of the condition of the Wessex input pinion. This enhancement gives a representation of the variation in tooth meshing action during one complete revolution of the gear.
- (e) **Kurtosis:** The 'Kurtosis' value is a statistical indicator used in the assessment of the condition of the input pinion. It measures the non-uniformity of the enhanced signal average.
- (f) **Condition:** The 'Condition' is given based on the Kurtosis value. A condition of ****GREEN**** (kurtosis less than 3.5) indicates that there is no substantial difference in the meshing of each tooth, ****AMBER**** (kurtosis between 3.5 and 4.5) indicates that there may be a problem with the gear and ****RED**** (kurtosis greater than 4.5) indicates more certainly that there is a problem with the gear.

5.2 Phase Plot.

A further analysis technique is provided which is referred to as the PHASE PLOT. This function can be used to confirm the presence (or absence) of a crack when the condition assessment is in the ****AMBER**** or ****RED**** ranges, as will be explained later.

Selecting the option marked PHASE PLOT will produce the phase plot for the currently selected file. NOTE: the selected file name is displayed in the 'file' section of the status line. If this is not the required file or is blank, you must select the correct file before running this function (see SELECTING A FILE).

The phase plot is drawn on the terminal screen and the program waits for the user to hit a key. The computer will NOT prompt for an input at this stage as any prompt would corrupt the phase plot.

To draw the phase plot on the printer, press the letter P. The computer will beep to indicate that it has received the command. The letter P will not appear on the screen as it would corrupt the plot. There will be a pause of a few minutes while the computer formats the plot for output to the printer, and then the plot should appear on the paper.

If you don't want to plot the graph on the printer, hit any key other than P, and the computer will return to the Wessex Pinion Signal Averaging menu.

6. INTERPRETATION OF RESULTS - WESSEX PINION SIGNAL AVERAGES.

6.1 Interpretation of the Signal Average.

The information given in the automatic analysis of the signal average provide a number of different indicators which can be used to assess the condition of the Wessex input pinion.

- (a) **The Graph:** Normally, the peaks and troughs should be of fairly uniform height and shape across the length of the plot. If one or a few peaks stand out from the rest (i.e. much larger or smaller), this could indicate that some localised tooth damage is present. This type of

fault will be picked up by the 'condition assessment' parameter and you should follow the procedures listed under 'condition' below.

- (b) **RMS Level:** The RMS level should not vary greatly from previous signal averages for the same gearbox. If large increases occur in the RMS level over successive recordings for the same gearbox, it could indicate wear on the input pinion. These increases should also be apparent in the spectrum analysis and would normally be accompanied by increases in the iron content of the oil. ARL should be contacted in the event of large increases in the RMS levels.
- (c) **Largest Component:** If the largest component is not an integral multiple of 22, you will see a line below this saying that it is not a meshing component. In this case, it probably means that there is something wrong with the recording. Re-check the tape to ensure that you have not made a mistake. If everything appears OK, delete the current signal average (see DELETING A FILE) and repeat the recording procedure. If you get the same results, inform ARL as further analysis of the data will be needed.
- (d) **Condition:** If the condition is given as ****AMBER**** or ****RED**** follow the procedures given below.

WARNING: Condition ****GREEN**** does not mean that there is nothing wrong with the gearbox - it only indicates that no crack exists in the input pinion. Analysis of the frequency spectrum and oil samples should still be used to determine the overall condition of the gearbox.

6.2 Condition ****AMBER**** or ****RED****.

If you have a condition ****AMBER**** or ****RED**** warning, it indicates that there is an inconsistency in the meshing of the gear. This can be due to a crack in the gear, localised damage to a tooth surface or the presence of a 'ghost' component. You will need to look at the PHASE PLOT of the signal average to determine the cause of the problem (see 'Interpretation of Phase Plot' below).

If the phase plot gives no indication of a crack, then there may be damage to the tooth surface, such as pitting. If this is the case, you should have some other indication such as an increase in iron in the oil analysis. This condition is not as serious as a crack and the iron content and visual inspection can be used as a guide to the degree of damage. Note that this system was designed specifically to detect cracks and will only detect pitting if it is localised to a small number of teeth - it will not detect pitting which is uniform on all teeth.

Some Wessex input pinions have a 'ghost' frequency, which appears to be a vibration produced by errors in the equipment used in producing the gear. The presence of the 'ghost' frequency does not indicate a problem with the gear. However it occurs at 25 orders for the Wessex input pinion, which is close to the fundamental tooth mesh (22 orders). If the largest component is at 22 orders, the 'ghost' can have a disruptive influence on the analysis and cause misleading results. If the system gives a warning and the phase plot does not show the characteristics of a cracked gear, the tape should be sent to ARL for further analysis.

6.3 Interpretation of the Phase Plot.

The Phase Plot gives a further indication of a crack in the input pinion. When you produce a phase plot, you will see a graph which has a square border and a small cross in the middle, indicating an origin. To the right of the origin, you will see a bunch of squiggly lines which appear to be centred on a single point; this is the phase plot of the signal average (see Figure 4). If one or more loops appear to come out of the main bunch in the direction of the origin, then this indicates that the gear has a crack (see Figure 5).

If there are no obvious loops coming from the main bunch, then the gear is not cracked. As a rule of thumb, an 'obvious' loop will protrude about twice as far from the centre of the bunch as the rest of the loops.

7. STOPPING THE SYSTEM.

Before switching the system off, select the EXIT function from the Wessex Pinion Signal Averaging or Main menu. This function will perform system housekeeping functions (e.g. transfer any new files to floppy disk) and halt the computer.

You can shutdown the system at any time by just turning it off, however this will leave all new files on the system hard disk. These can clog up the system if you never perform an EXIT. They may also be lost in the event of a hard disk failure.

After EXITing the system, make sure you remove any floppy disk from the disk drive. You will find the computer has stopped and will not respond to any input from the keyboard. Turn the key anti-clockwise to turn off the computer. You can restart the system without turning off the computer by pressing the RESTART button on the computer front panel.

8. SELECTING A FILE.

To select a file (existing signal average) for use with the ANALYSE AVERAGE or PHASE PLOT options, follow these steps from the Wessex Pinion Signal Averaging Menu:

- (a) Select the device on which the file resides by using the SELECT DEVICE option. The two devices from which you can select a file are 'WP:' and 'DY:'. These are the Wessex Pinion hard disk area and the floppy disk drive respectively.

When you pick SELECT DEVICE, the current default device (either WP: or DY:) will be displayed and you will be asked whether you want to change device. If you enter Y, the default device will toggle to the other device. If you enter N, the default device will remain unchanged.

- (b) Pick the SELECT FILE option. A list of signal averages on the currently selected device will be displayed on the screen. Move the cursor to the file you want, using the cursor keys, and press the RETURN key to select the file. If there are more files than will fit on one screen, you can use the NextScrn and PrevScrn keys to move between screens. If you decide not to select any of the files, press Q to return to the Wessex Pinion Signal Averaging menu.

When you select a file, the file name (preceded by the device name) will appear in bold type in the 'File' section of the status line.

9. DELETING A FILE.

To delete a signal average, select the DELETE FILE option in the Wessex Pinion Signal Averaging menu. Use this with caution as the signal average you delete will no longer be accessible. This function should only be used to delete a signal average which is corrupted; for example, if you inadvertently used a Sea-King tape instead of a Wessex tape.

Choose the file to be deleted in the same manner as selecting a file (described above) and press RETURN to delete it. The computer will ask for confirmation before deleting the file. If the deleted file is the last created or selected file, as will often be the case, the file name displayed in the status line will be replaced by a row of dots to indicate that the currently selected file has been deleted and is no longer accessible.

To exit the DELETE function without deleting a file, press Q (for Quit).

10. REPEATING AN ANALYSIS.

To repeat the analysis if the original results have been lost or were not printed correctly (due to printer not being switched on, paper misaligned etc.), first select the file containing the signal average to be analysed (see SELECTING A FILE) then select the ANALYSE AVERAGE option from the Wessex Pinion Signal Averaging menu. This performs the same analysis as that run at the end of the AUTO option.

11. PREPARING NEW FLOPPY DISKS FOR USE.

In order to use new floppy disks, they must first be initialized. To do this you need to run the INIT FLOPPY option in the Wessex Pinion Signal Averaging menu or the Main menu. You should ensure that you have at least one spare initialized disk at all times.

When you select INIT FLOPPY, the computer will prompt you to insert a new floppy disk in the drive. Place the disk in the drive and close the door then press RETURN. The red light on the front of drive should come on and the drive will make a slow clunking noise - this is normal. The initialization will take a few minutes. If anything does go wrong the computer will give you a message. After the disk is initialized you should see the message:

?DUP-I-No bad blocks detected DY0:

This indicates that the disk is correctly initialized and contains no bad blocks. If the computer indicates that there are bad blocks on the disk, then discard the disk.

The computer will now ask if you wish to initialize another disk. It is recommended that whenever you get a new box of disks, you initialize ALL of the new disks. Place a blank label on the initialized disks to identify them as empty, initialized disks.

12. MAIN MENU.

The Main Menu will provide a link between sub-systems when more functions are added to the system (see Figure 2). At the moment, the only time you will ever need to go to the main menu is when you need to install an updated system or to make a copy of a floppy disk.

13. COPYING A FLOPPY DISK.

It is a good idea to periodically copy (back-up) your floppy disks to prevent a loss of data if a floppy disk becomes damaged. You may also need to copy a floppy disk in order to send data to ARL for further analysis of signal averages.

Select the COPY FLOPPY option from the main menu. To move to the main menu from the Wessex Pinion Signal Averaging menu, select the MAIN MENU option.

The computer will prompt you to place the disk to be copied in the drive. Do this and close the drive door, then press RETURN. The drive light should now come on for awhile, while the computer copies the disk to memory. You will then be prompted to place a new disk in the drive. WARNING: any data already on this disk will be overwritten. Remove the original disk from the drive, replace it with the new disk and close the drive door. The red light on the drive will come on again, and you will hear the drive working as the disk is written to. When the copy is complete, make sure you label the new disk.

It is recommended that you keep two copies of your Wessex Pinion Signal Averages floppy disks. One is your normal working disk and the other (with the word BACKUP added prominently) being a backup disk. Each week, copy the current Wessex Pinion Signal Averages disk to its backup disk. This will maintain two copies of your data, in the event that one disk becomes corrupted.

14. INSTALLING A NEW SYSTEM.

To install any new version of the system which will be provided from time to time by ARL, select the INSTALL NEW SYS option in the MAIN MENU. The computer will ask you to put the new system disk in the disk drive. If there is more than one disk, put the one marked Disk 1 in the drive. The new system will then install itself and automatically boot up.

NOTE: Along with the new system, you should receive any updates required to this manual, or a new manual replacing this one, unless the system is functionally identical (i.e. provided only to fix any bugs in the current system).

15. SEA-KING.

By selecting SEA-KING in the MAIN MENU, you will enter the Sea-King menu. As there is no Sea-King sub-system at present you will see only two options; 'Wessex' and 'Main Menu'. These will move to the Wessex Pinion Signal Averaging or Main menu respectively.

APPENDIX A - SHORT FORM GUIDE

Analyse Wessex Tape:	Connect tape recorder channel 2 output to filter channel 1 input. Connect recorder channel 4 output to filter channel 2 input. Turn on filter, position tape, turn tape speed to 1.5 IPS and select AUTO from WESSEX menu.
Copy a Floppy Disk:	Select COPY FLOPPY option in MAIN MENU. Follow the instructions the computer gives.
Enter Text:	Type the text to be entered and press RETURN key.
Load a New System:	Select INSTALL NEW SYS option from MAIN MENU. Follow the instructions the computer gives.
Move Cursor:	<p>The arrow keys (\uparrow, \downarrow, \leftarrow, \rightarrow) on the small keypad to the right of the main keyboard, will move the cursor in the direction of the arrow.</p> <p>The diagonal arrow (\swarrow) moves the cursor to the top left of the screen. If the cursor is already at the top left, it will move to the bottom right.</p> <p>NextScrn and PrevScrn will move between screens in multi-screen options.</p>
Print a Phase Plot:	With the phase plot on the screen, press the key P.
Select Option or File:	Place the cursor on item to be selected and press the RETURN key.
Set-up New Floppy Disk:	Place floppy disk in drive and select the INIT FLOPPY option.
Shut Down System:	Select the EXIT option. Turn off the system when instructed to do so, and switch off the power.
Start Up System:	Turn on power and turn key in system unit clockwise.

APPENDIX B - CARE AND MAINTENANCE.

Floppy Disks.

- (a) **ORDERING.** Use only 8 inch Double Sided, Double Density disks. A number of brands are available. Choose any of the well known brands (e.g. Xidex, Verbatim, Memorex, Fuji); these are all much the same. They usually come in boxes of ten. One box should last you a long time. You will get about 200 signal averages on one disk.
- (b) **INITIALIZE** all the new floppy disks when you get a new box. Place a write enable tag (small silver tag supplied with disks) on each disk over larger of the three notches in the disk cover. **HINT:** put a blank label on the initialized floppy disks so you know they are usable and don't contain any data.
- (c) Always store floppy disks in their dust jackets.
- (d) Don't touch the surface of a floppy disk.
- (e) Don't leave floppy disks in the disk drive when you turn off the computer.
- (f) Store floppy disks away from direct sunlight, dust, and magnetic interference such as electrical equipment.
- (g) Always keep at least one unused, initialized floppy disk on hand.
- (h) Use only FELT-TIPPED pens to write on floppy disk labels.
- (i) Write a label on each used floppy disk so you know what it contains.
- (j) Keep a BACKUP disk for each data disk. Copy the current data disk to the backup disk once a week (using the COPY FLOPPY command).

Printer.

(a) Paper

- Use normal fan-fold (tractor feed) computer paper. This can be from 8 to 15 inches wide (use 9.5 inch for preference). A plain white (unlined) paper will give best results. Refer to page 97 of the Toshiba P351 User's Manual for weight restrictions, etc.
- Refer to page 37 of the Toshiba P351 User's Manual for instructions on loading paper. For best results, follow the instructions for loading the paper from behind the printer.
- You should align the paper so that the far left edge is as close to the left edge of the printer as possible.

(b) Ribbon

- The print ribbon is of the cartridge type and should last for a long time. When ordering ribbons, make sure they are of the correct type (suitable for Toshiba P351 model 2). One box of ribbons (usually 6 or 10) will last for a number of years.
- When the print becomes dull the ribbon should be replaced.
- Refer to page 22 of the Toshiba P351 User's Manual for instructions on how to replace the ribbon.

(c) Cleaning

- Refer to page 62 of the Toshiba P351 User's Manual (Care and Maintenance) for cleaning instructions.

Other Hardware.

No special maintenance is required for the other hardware (system unit, terminal and filter), however these should be kept clean and free of dust.

APPENDIX C - HARDWARE INSTALLATION AND SET-UPS.

Hardware Description

The hardware purchased to run the RAN Vibration Analysis System was chosen for compatibility with hardware already in use at ARL on which the system software was developed. The system consists of:

- (a) A Webster Spectrum system unit which includes
 - An LSI 11/73 processor
 - A 20 megabyte hard disk
 - An 8 inch floppy disk drive
 - 1 megabyte of memory
 - A 12-bit Analogue-to-Digital Converter
 - A real time clock unit
 - A multifunction board (4 serial lines plus an automatic bootstrap unit)
- (b) A Visual 240 video/graphics terminal
- (c) A Toshiba P351 24-pin dot matrix printer/plotter
- (d) A Wavetek brickwall filter. This is a dual channel low-pass filter which is used as an anti-aliasing filter for input of analogue signals to the Analogue-to-Digital converter.
- (e) Also required as part of the system is an FM tape recorder. The Bruel & Kjaer tape recorders already in use at NAS Nowra are suitable for this purpose.

Location.

The system should be located in a relatively dust free environment and away from direct sunlight. The system unit contains two cooling fans with inlets at the rear and an outlet at the front panel. Both the inlets and outlet should be kept clear to allow sufficient air to flow through the system.

Connections.

ARL has supplied all the cables necessary to connect the system components together. These cables are labelled, as are the connectors in the various components. Figure 6 shows the location of the connectors on the system components.

Make sure that all cables are securely connected and labelled. If any of the labels come off, re-attach them or make a new label and attach this to avoid confusion if the system ever needs to be disconnected at a later date.

The following is a list of the connections required:

Power:	The terminal power plug should be plugged into the power outlet on the rear of the computer. All other plugs should go to standard 240 Volt mains power points.
Terminal Logic Unit - VDU:	Use the cable marked TERMINAL on one end and VDU on the other. Plug in and secure the end marked 'terminal' into the 'VDU' outlet on the terminal logic unit. Plug in and secure the end marked 'VDU' to the VDU.
Keyboard - Terminal:	Plug the keyboard connecting cable into the 'keyboard' outlet on the rear of the terminal logic unit.
Terminal - Computer:	Two connecting cables are required between the terminal and the computer. One cable has 25-pin plugs on each end; plug the one marked 'terminal' into the 'COMMS' port on the rear of the terminal logic unit and secure it, then plug the end marked 'computer' into the 'terminal' port of the computer and secure it. The other cable has a 25-pin plug at one end and a 9-pin plug at the other; plug the 9-pin 'terminal AUX-1' into the 'AUX-1 (Printer)' port on the rear of the terminal logic unit and secure it, then place the 25-pin 'computer AUX-1' into the 'AUX-1' port on the computer and secure it.
Computer - Printer:	Use the cable with ends marked 'printer' and 'computer'. Connect the end marked 'computer' to the 'printer' port on the computer and secure it. Plug the end marked 'printer' into the 25-pin connector on the rear of the printer and secure it.
Filter - Computer:	The filter is connected to the computer by two BNC leads. Connect 'filter out 1' to 'OUT1' on the front of the filter, connect 'filter out 2' to 'OUT2' on the front of the filter, connect 'ADC in 1' to 'ADC IN 1' on the rear of the computer and 'ADC IN 2' to 'ADC IN 2' on the rear of the computer.
Tape Recorder - Filter:	The tape recorder and filter are connected by two BNC leads. Connect 'filter in 1' to 'IN1' on the front of the filter and connect 'filter in 2' to 'IN2' on the front of the filter. The recorder will

probably be connected and disconnected fairly often, however it is convenient to leave the leads connected at the filter end. To connect the recorder, connect 'recorder out 2' to the channel 2 output of the recorder and 'recorder out 4' to the channel 4 output.

Filter Settings.

For Wessex Pinion Signal Averaging, the filter should be set up as follows:

Both AC/DC switches in the AC position.

Both Gain dials in the '0' position.

Channel 1 filter setting: '4' '2' X '10'

Channel 2 filter setting: '4' '1' X '1'

These values may change for other analysis functions added in the future but for the moment, leave the filter on this setting all the time.

Set-ups.

The terminal and the printer have a means of setting a number of options which control the way they work. These have been pre-set at ARL and should not have to be changed. If either of these items have to be repaired or replaced due to failure, the set-ups should be checked as follows:

Printer: The printer set-up is controlled by four banks of DIP switches which are accessed by lifting the front cover. The switches are grouped together on the right front. They should be set as shown in Figure 7. Set the switches with the printer turned off. If you need to use any other printer for some reason, the following is a list of the default settings required. NOTE that any printer used must have IBM or EPSON graphics compatibility - otherwise the software will not drive it.

Communications - XON/XOFF protocol, 9600 Baud (BPS), 8 data bits, 1 stop bit, no parity.

Print modes - 11 inch form (66 lines), Bi-Directional printing, truncate long lines, IBM/EPSON escape sequences, USA character set, High quality prestige Elite font, 12 Characters per inch.

Terminal: The terminal is set up using in-built menus. Any terminal used with this system must be DEC VT240 compatible. In order to access the menu, run the terminal by itself by plugging the terminal into a normal power point instead of the computer power outlet. Press the key marked SET-UP on the top left of the keyboard. You should see a line across the bottom of the screen with a number of options in reverse video. Use the arrow key to move the highlight to the 'Directory' option on the far right. Now press the ENTER key on the bottom right of

the keyboard. You should now see the Directory Menu (Figure 8(a)) which has a number of options which go to other set-up menus (Display, Communications etc.). Refer to Figure 8 which shows how each set-up menu should look (except the AUX menu, which is not used). Go to each menu in turn using the arrow keys and ENTER to select each option. Make sure that each menu has the same settings shown in Figure 8. To change a setting, move the highlight onto it and press ENTER; this will toggle through the available settings - stop when it is the same as that shown in Figure 8. When the setting is correct return to the main set-up directory by selecting the 'Directory' option and then select the next set-up. When all the set-ups are as shown in Figure 8, select the 'SAVE' option in the main set-up directory and press ENTER. The settings will now be saved and will not have to be changed again.

APPENDIX D - SYSTEM FAILURES.

Software

Although all care has been taken by ARL to ensure that you should not have any problems with the software, there is a chance that the software contains some 'bugs' which have not been found or that you do something unexpected which causes the system to 'crash'.

In either case, you should inform ARL of the problem and we should be able to modify the software and send you an updated system during the problem. In the interim, you should be able to restart the system by pushing the RESTART button on the front of the system unit. Make sure there is not a floppy disk in the drive when you do this. Depending on where the fault occurred, you should not lose any data. If the problem was in the AUTO routine, you may have to read in the tape again - check if a new signal average was created by using the SELECT FILE option. If a file was created, select it and run the Analyse Average option if required.

Hardware.

If the system 'crashes', it may not be a software fault but some problem with the hardware. This is a lot more difficult to diagnose. If the system does not start up normally (i.e. does not ask for the date and time or does not show the system menu), then there is a good chance that the hardware is at fault and you will have to call a computer technician. He should be able to track down any hardware fault and replace a component if required.

NOTE: If the hard disk requires replacing you will have to re-load it with the operating system as well as the current vibration analysis system. This requires that the hard disk is first formatted and checked. The computer technician who installs the disk should do this. After the disk has been formatted and checked, place the floppy disk marked 'RT11 (NAS) SYSTEM DISK 1' (supplied with the system by ARL) in the floppy disk drive with the computer turned OFF and then turn the computer on (make sure that everything is connected - see INSTALLATION). The computer will instruct you what to do from here. You will have to insert a number of disks - make sure they are the exact ones the computer asked for, otherwise the system may not perform correctly.

If any of the other hardware is replaced, make sure it is set-up correctly as detailed in 'INSTALLATION'. Any internal boards replaced should be configured by the technician to be identical to the one removed.

APPENDIX E - MOVING THE SYSTEM.

If the computer needs to be moved to another site, the hard disk must be positioned on the SHIPPING ZONE to avoid loss of data or damage to the heads. To do this, you will need to use a system utility which manages the hard disk. Follow these instructions EXACTLY:

- (a) Select the EXIT option as you would normally do before shutting down the computer.
- (b) When the line 'EXIT SYSTEM - Are you sure (Y/N)' appears, type in HD and press the RETURN key. This will run the system hard disk utility (which is actually called Wombat).
- (c) You will see a number of options listed and you will be prompted to select one. Enter the number 5 and press RETURN. This should be listed as 'Position Head on Shipping Zone.' If another number appears in front of this entry, then enter the other number instead of 5. The computer will respond: 'Disc Head now on SHIPPING ZONE', and then repeat the menu. DON'T RUN ANY OTHER OPTION as this may cause data on the hard disk to be lost.
- (d) Turn off the computer.

The floppy disk drive heads also need to be protected during transport. To do this, place the cardboard head protector which came with the computer in the disk drive. If you have lost this, place an UNUSED floppy disk in the drive and close the door - label this floppy disk 'Head Protector' and don't use it to store data.

When transporting the system, try not to subject any of the components to undue shock. If the system is being moved some distance (so it will not be carried by hand) then it should be re-packed in the original boxes.

Refer to the INSTALLATION appendix to set-up the system in its new location.

REFERENCES

- [1] Data Translation Inc., "User Manual for DT2762 Series Analog Input System," 1984.
- [2] Data Translation Inc., "User Manual for DT2769, DTKWV11-C Real Time Clock," 1986.
- [3] Digital Equipment Corporation, "KDJ11-A CPU Module User's Guide," 1986.
- [4] Digital Equipment Corporation, "RT-11 Mini-Reference Manual (Version 5.2)," November 1985.
- [5] Toshiba Corporation, "User's Manual, P351 Model 2," 1986.
- [6] Visual Technology Incorporated, "Visual 240/241 User's Guide," December 1985.
- [7] Wavetek San Diego Inc., "Instruction Manual. Models 751A, 752A, and 753A Brickwall Filters," 1984.
- [8] Webster Computer Corporation, "PCLV11-J Multifunction Unit Technical Manual," Version 1.0.
- [9] Webster Computer Corporation, "SMSV11-D Memory Module User Manual," Version 1.0.
- [10] Webster Computer Corporation, "SRQD11-A Winchester Disc Controller User Manual," 1985.

RAN VIBRATION ANALYSIS SYSTEM

Version 2.1

WESSEX PINION SIGNAL AVERAGING

File:

AUTO	SELECT DEVICE
SELECT FILE	DELETE FILE
ANALYSE AVERAGE	PHASE PLOT
INIT FLOPPY	MAIN MENU
EXIT	

Use arrow keys to position cursor, <RETURN> to select option

FIGURE 1 - Wessex Pinion Signal Averaging Menu.

RAN VIBRATION ANALYSIS SYSTEM

Version 2.1

MAIN MENU

File:

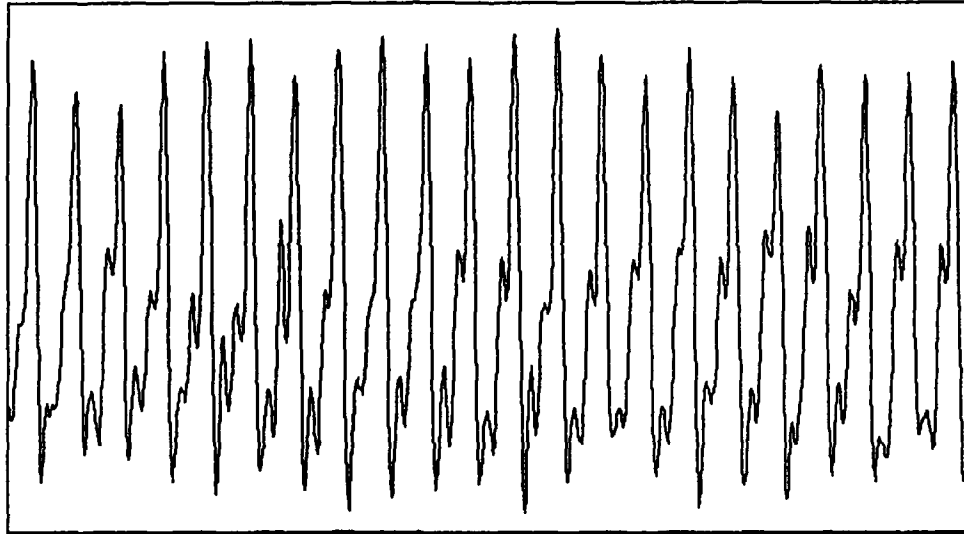
WESSEX	SEA KING
INIT FLOPPY	COPY FLOPPY
INSTALL NEW SYS	EXIT

Use arrow keys to position cursor, <RETURN> to select option

FIGURE 2 - Main Menu.

WESSEX PINION SIGNAL AVERAGING

Program ANLAVG Version 2.1



File name.....WP:WAK148.012

Component.....WIP

Gearbox serial number.....WAK148

Hours since overhaul.....560.9

Tape number.....2-88

Date recorded.....14-1-88

Torque.....400

Largest component..... 22

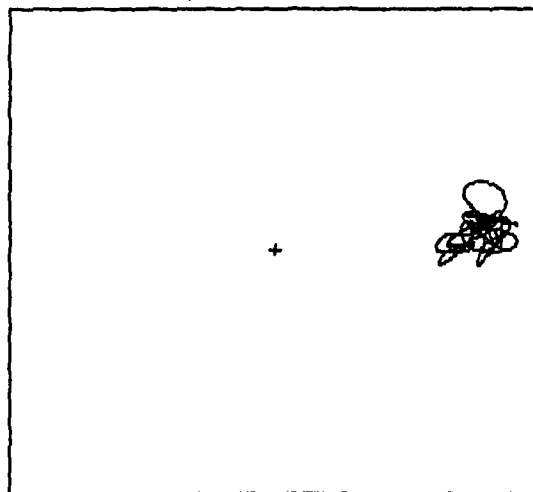
Pass band lower limit..... 8

Pass band upper limit..... 36

Kurtosis..... 3.0

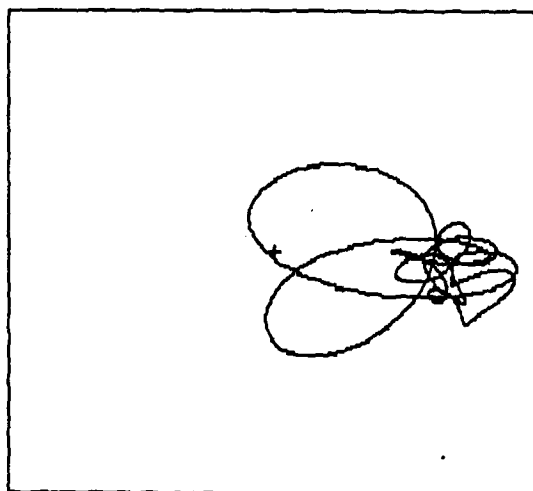
Condition.....GREEN

FIGURE 3 - Analysis of Signal Average.



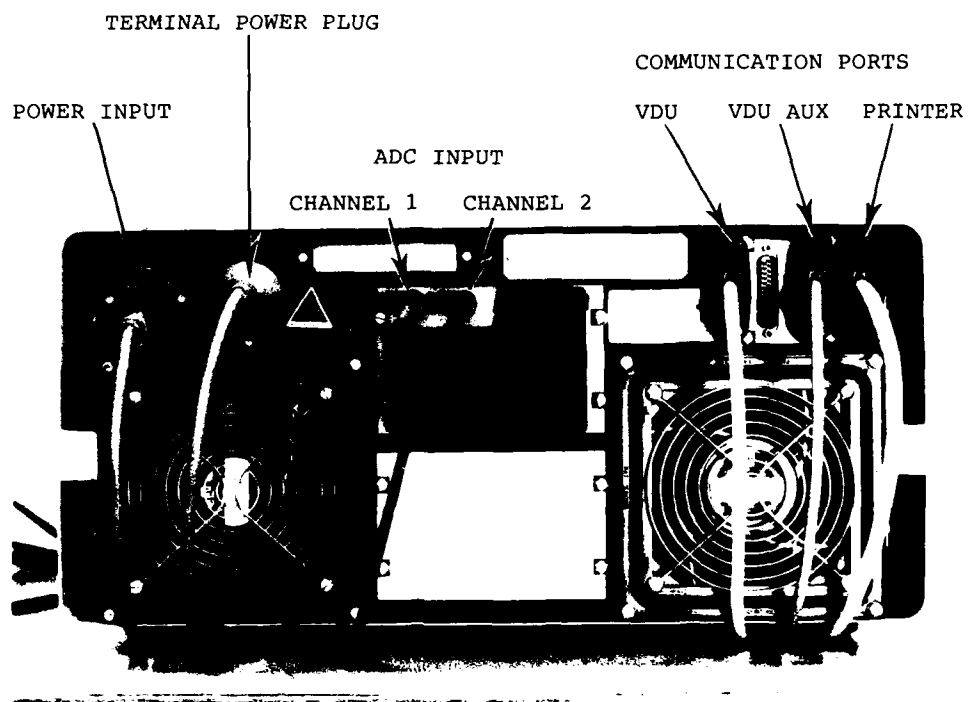
Component WIP
Gearbox WAK148
Hours 560.9
Tape 2-88
Date 14-1-88
Torque 400

FIGURE 4 - Phase Plot of Pinion without crack.

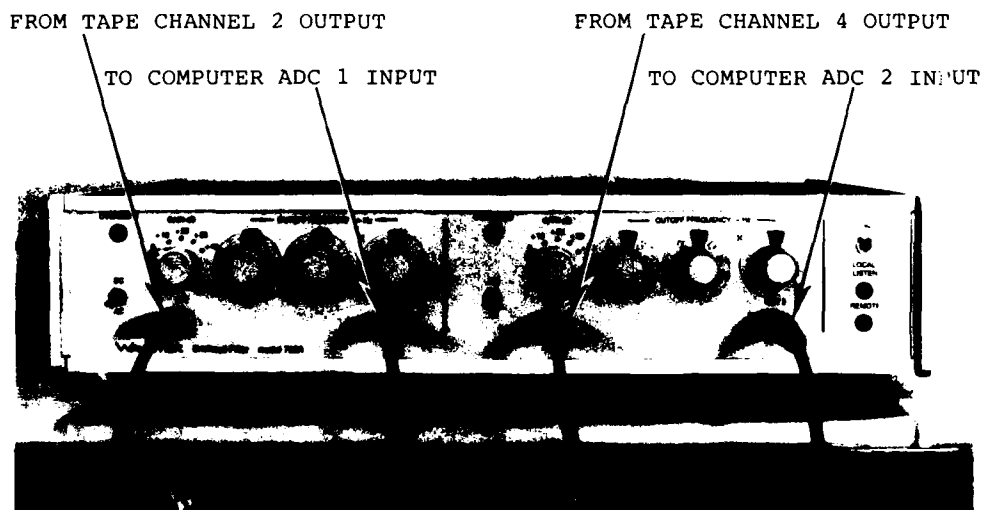


Component WIP
Gearbox WAK143
Hours 324.3
Tape 29-83
Date 11-10-83
Torque 300

FIGURE 5 - Phase Plot of Cracked Pinion.

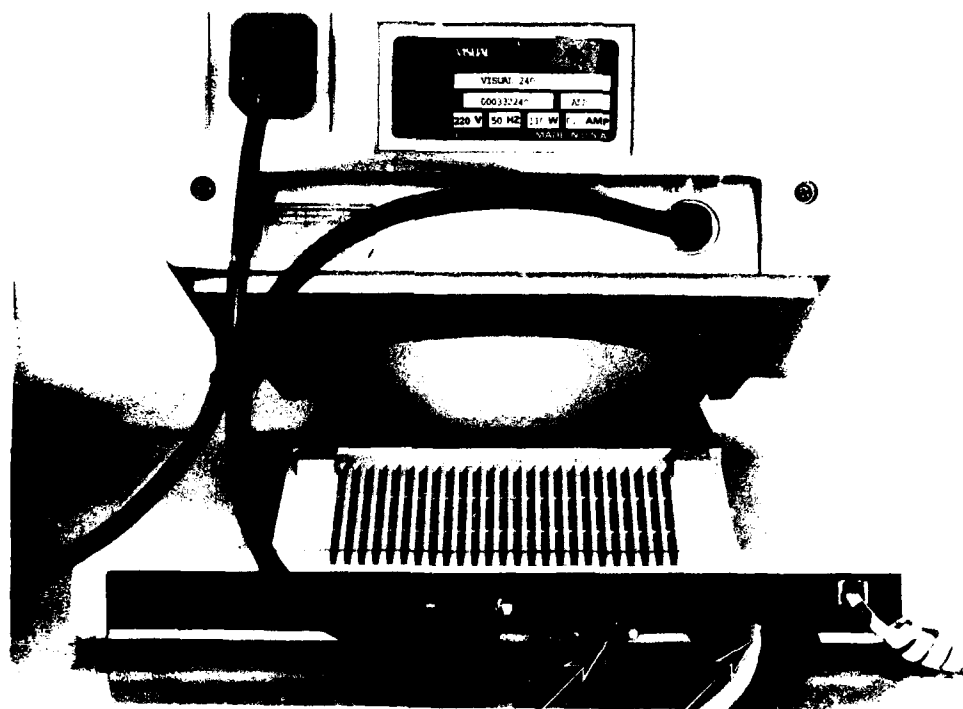


6(a) SYSTEM UNIT



6(b) LOW-PASS FILTER

FIGURE 6 - CONNECTORS



COMMPORT: TO COMPUTER VDU PORT

AUXPORT: COMPUTER VDU AUX PORT

6(c) VDU

FIGURE 6 - CONNECTORS (cont.)

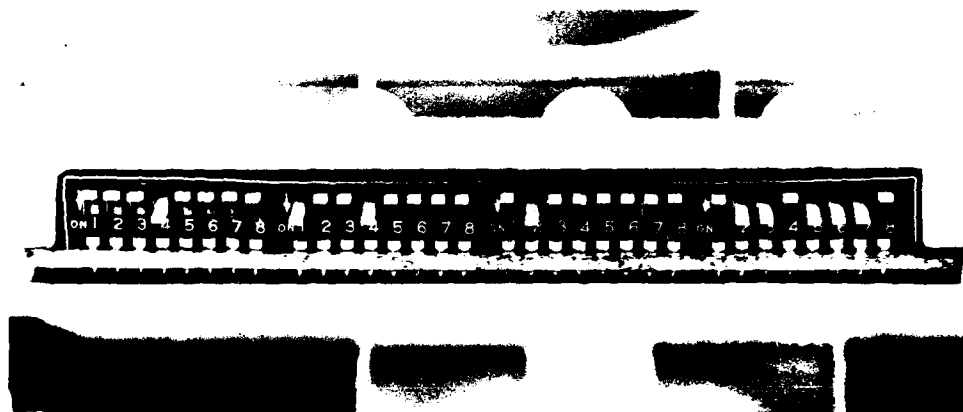


FIGURE 7 - PRINTER DIP SWITCH SETTINGS

Set-Up Directory

240 V1.6

Display General Comm Printer Keyboard Tab Graphics Aux.
On Line Clear Display Clear Comm Reset Terminal Recall Save
Set-Up=English North American Keyboard Default Exit

(a) Directory Set-up

Display Set-Up

240 V1.6

To Next Set-Up To Directory 80 Columns Interpret Controls
No Auto Wrap Jump Scroll Light Text,Dark Screen Monochrome Display
Text Cursor Block Cursor 24 Lines No Status Line

(b) Display Set-up

General Set-Up

240 V1.6

To Next Set-Up To Directory VT200 Mode, 7-Bit Controls
User Defined Keys Unlocked User Defined Features Unlocked
Numeric Keypad Normal Cursor Keys No New Line VT240 ID

(c) General Set-up

Communications Set-Up

240 V1.6

To Next Set-Up To Directory Transmit = 9600 Receive=Transmit
XOFF at 256 8 Bits, No Parity 1 Stop Bit No Local Echo
EIA Port, Data Leads Only Disconnect, 2 s Delay Limited Transmit

(d) Communications Set-up

FIGURE 8 - Terminal Set-Ups.

Printer Set-Up

240 V1.6

To Next Set-Up To Directory Speed = 9600 No Printer to Host
Normal Print Mode XOFF 8 Bits, No Parity 1 Stop Bit
Print Full Page All Characters Terminator = FF

(e) Printer Set-up

Keyboard Set-Up

240 V1.6

To Next Set-Up To Directory Typewriter Keys Caps Lock
Auto Repeat Keyclick No Margin Bell Warning Bell Break
No Auto Answerback Answerback= Not Concealed

(f) Keyboard Set-up

Graphics Set-Up

240 V1.6

To Next Set-Up To Directory Graphics Cursor No Macrograph Report
4010 CR Effect = CR 4010 DEL Implies Delete Compressed Print
4010 LF Effect = LF 4010 GIN Terminator = CR

(g) Graphics Set-up

FIGURE 8 - Terminal Set-Ups (continued)

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